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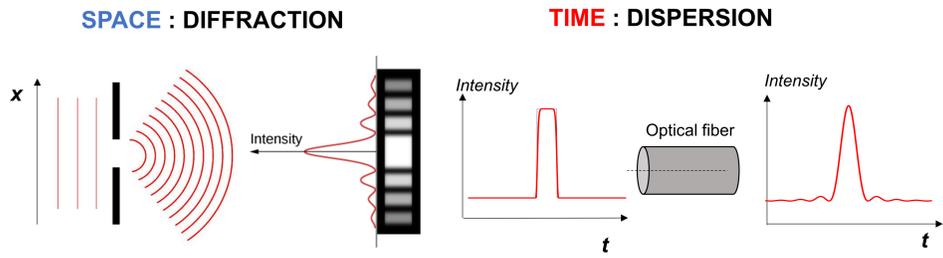
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Temporal analogue of the **Fresnel diffraction** by a phase plate in **linear and nonlinear optical fibers**

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Introduction

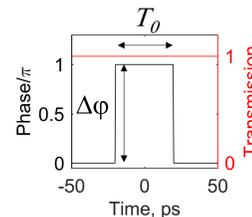
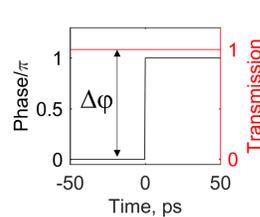
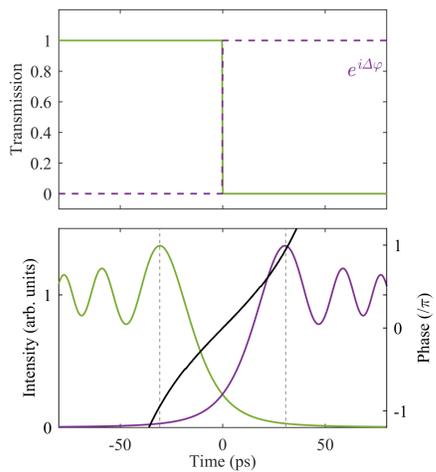


⇒ we can observe spatial phenomena in the ultrafast optics
⇒ we consider Fresnel diffraction on phase plates

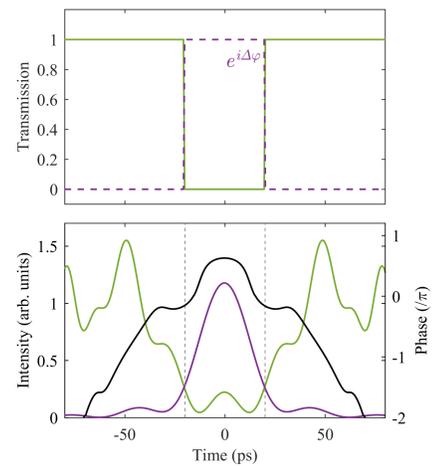


INTERPRETATION

Single phase transition



Double phase transition

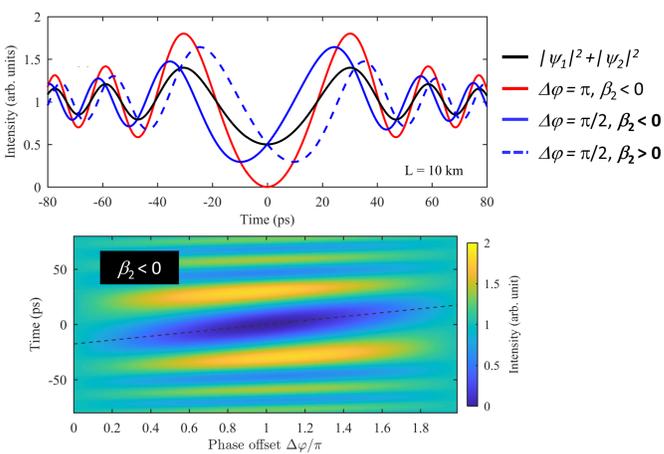


The phase transitions can be decomposed into **two semi-infinite screens** or into **opaque stripe and slit**, with one of the components additionally imprinting $\Delta\phi$ phase.

Output wave is the result of **two-waves interference**, where the intensity profile is defined by **the phase difference** (black lines) and is highly-dependent on $\Delta\phi$.

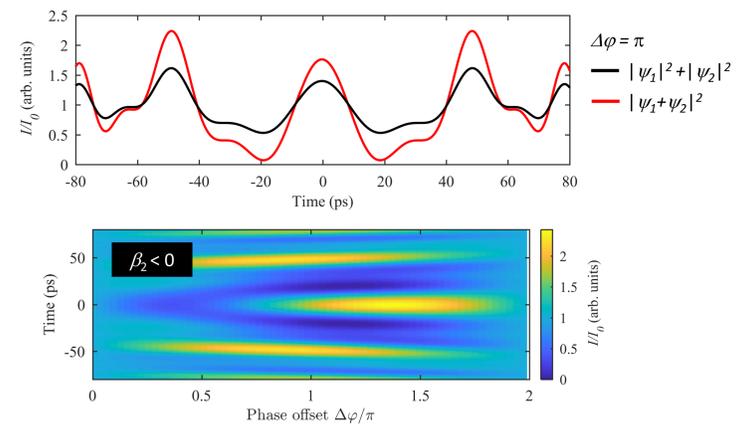
In all numerical (analytical) simulations we consider propagation in 10 km SMF-28 fiber with $\gamma = 1.1 / \text{W/km}$, $\beta_2 = \pm 20 \text{ ps}^2/\text{km}$

LINEAR PROPAGATION

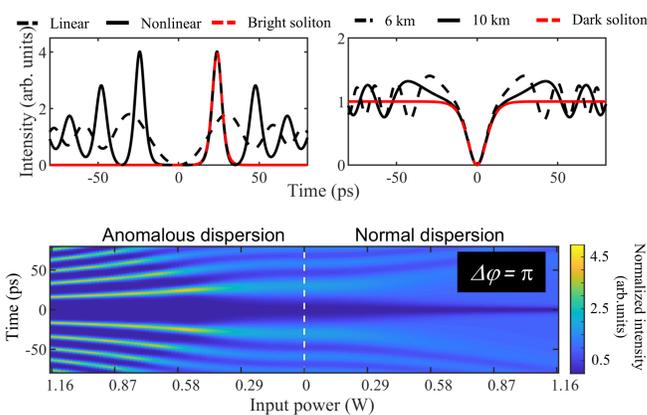


The waveforms are described by the **Fresnel integrals** (with the respective treatment and transitions to fiber optics).

- for the **single phase jump** one observes asymmetric profiles depending on $\Delta\phi$ and regime of dispersion
- for the **double phase jump** the intensity profiles are always symmetric with respect to $t = 0$, however it can be flipped with respect to $\Delta\phi = \pi$ in case of the opposite dispersion regime



NONLINEAR PROPAGATION

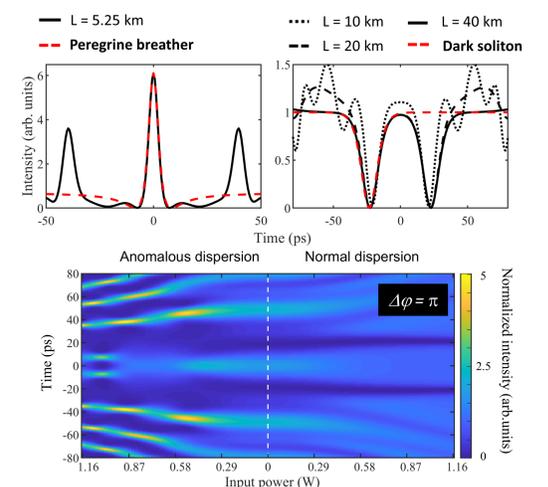


Nonlinear Schrodinger equation (NLSE) :

$$\frac{\partial a(t, z)}{\partial z} + i \frac{\beta_2}{2} \frac{\partial^2 a(t, z)}{\partial t^2} + i \gamma |a(t, z)|^2 a(t, z) = 0$$

Existing intensity peaks trigger nonlinear effects leading to formation of **coherent structures** throughout the propagation :

- **bright and dark solitons** in case of the single phase jump
- **a Peregrine breather and a pair of dark solitons** in case of the double phase jump



Conclusion

We study temporal intensity patterns emerging from diffraction by a phase plate.

- the results are interpreted in terms of interference of the diffracted waves on edge, stripe and slit
- in case of purely linear evolution a complete analytical framework is provided
- Kerr nonlinearity leads to the emergence of coherent structures

References

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